Site Characterization Using Horizontal Boring/Drilling Technology

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THE PROBLEM

Contaminant sources are often located beneath surface obstructions. In the case of Dense Non-Aqueous Phase Liquids (DNAPLs), they tend to pool along the contour of an aquitard or stratified horizontal fine-grain soil formations. These factors limit the usefulness of vertical characterization methods.

THE APPROACH

AFRL/MLQ is researching the adaptation of a hydrocarbon/DNAPL sensor for delivery in a horizontal borehole. Only the fiber optic cables and LIF module are delivered downhole, with the laser and associated hardware left at the surface. The sensor utilizes laser induced fluorescence (LIF) to detect petroleum contaminants and is also useful in DNAPL detection. Other organic molecules solvated in DNAPLs are responsible for the fluorescence. The research involved upgrading the laser spectrometer to multi-wavelength detection capabilities and optimizing wavelength and power output for longer distance transmissions. Laboratory tests verified that the laser spectrometer system is capable of detecting DNAPLs. Tests using DNAPL recovered from an Air Force base demonstrated a detection level of 57 ppm with 99 percent confidence.

A bottom hole assembly (BHA) was developed to deliver the LIF module in a horizontal borehole. The BHA consists of the LIF module mounted on the exterior of one of the bands of a pre-sprung centralizer with the fiber optic cables protected in a sealed conduit. The centralizer delivers the LIF module to the formation beyond the borehole wall and conforms to non-uniformities in the borehole. A geophysical logging tool can also be attached to the BHA for lithologic characterization.

Bottom Hole Assembly

The sensor is delivered by first drilling a horizontal pilot hole from the surface, through the zone of interest, and back to the surface. The BHA is then connected to the drill string and pulled back through the borehole, giving a continuous characterization of the contaminants and geophysical data along the path of the borehole.

FIELD TESTS AND RESULTS

A field test was conducted to test the delivery system. Two different locations with varying drilling conditions were chosen. Three horizontal boreholes were completed at depths ranging from 3 to 12 feet and lengths of 190 to 250 feet. A minimal amount of an organic polymer-based drilling fluid, which gives a good fluorescent signature, was used to verify that the LIF module was delivered beyond the borehole wall and any invasion of drilling fluids. A natural gamma geophysical tool was attached to the BHA during one test run to gather lithologic data. In all three trials, the LIF module was successfully delivered through the horizontal borehole; contact with the formation beyond drilling fluid invasion was verified. One of the drilling locations was near an abandoned oil production well. At this location, 64 feet into the borehole, the laser spectrometer detected a crude oil signature. Secondary confirmation of the source of the signature was provided by excavation at that location, where stained, crude oil contaminated soils were encountered. A second demonstration was successfully conducted at Kirtland AFB to characterize contamination **under** the base service station.

PAYOFF

With this technology, petroleum and DNAPL contaminant sources under surface obstructions and along confining layers can be characterized in a cost-effective and efficient manner with a minimum generation of investigative derived waste.

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